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Kozo OIKAWA
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[Inventor]

[Address] c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo

[Name] Yuichi YAMAGUCHI

[Inventor]

[Address] c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo

[Name] Hironori KIKKAWA

[Inventor]

[Address] c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo

[Name] Hiroshi KANOH

[Inventor]

[Address] c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo

[Name] Teruaki SUZUKI

[Inventor]

[Address] c/o NEC Corporation, 7-1, Shiba 5-chome, Minato-ku, Tokyo

[Name] Hidenori IKENO

[Applicant]

[Identification Number] 000004237

[Name] NEC Corporation

[Agent]

[Identification Number] 100086645

[Patent Attorney]

[Name] Yoshiyuki IWASA

[Telephone No.] 03-3861-9711

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[Document Name] Specification

[Title of the Invention] Reflection type liquid crystal display device and a method of fabricating the same

[Claims]

[Claim 1] A reflection-type liquid crystal display device comprising a liquid crystal layer sandwiched between a lower substrate and an opposing substrate arranged to face each other, and a reflection electrode which is formed on said lower substrate and at which an external incident light is reflected towards a viewer as a light source,

characterized in that

said lower substrate has a flat surface at which said lower substrate makes contact with said liquid crystal layer such that a gap between said opposing substrate and said reflection electrode or between said opposing substrate and said lower substrate on which said reflection electrode is formed is constant.

[Claim 2] The reflection-type liquid crystal display device as set forth in claim 1, wherein said reflection electrode is formed on an electrically insulating film having a wavy surface, said reflection electrode having a surface reflecting said wavy surface of said electrically insulating film.

[Claim 3] The reflection-type liquid crystal display device as set forth in claim 2, wherein said electrically insulating film is comprised of a projection formed on said lower substrate, and an insulating layer covering said projection therewith.

[Claim 4] The reflection-type liquid crystal display device as set forth in claim 3, wherein said projection is comprised of a plurality of linear projections randomly arranged in a plane defined by a rectangular frame, and connecting to one another at a certain bending angle.

[Claim 5] The reflection-type liquid crystal display device as set forth in claim 2, 3 or 4, wherein said electrically insulating film is situated in a gap formed between adjacent reflection electrodes on a wiring layer formed on said

lower substrate.

[Claim 6] The reflection-type liquid crystal display device as set forth in claim 5, wherein said electrically insulating film located in said gap on said wiring layer has a height equal to or greater than a height of a lowest portion of said wavy surface of said reflection electrode.

[Claim 7] The reflection-type liquid crystal display device as set forth in claim 5 or 6, wherein a rectangular frame of continuous projection is arranged on said wiring layer.

[Claim 8] The reflection-type liquid crystal display device as set forth in claim 5, 6 or 7, wherein said wiring layer and said reflection electrode are arranged such that an end of said wiring layer does not overlap an end of said reflection electrode.

[Claim 9] The reflection-type liquid crystal display device as set forth in claim 5, 6 or 7, wherein said wiring layer and said reflection electrode are arranged such that a side of said wiring layer is in alignment with an end of said reflection electrode.

[Claim 10] The reflection-type liquid crystal display device as set forth in any one of claims 5 to 9, wherein said projection formed on said wiring layer has a width greater than a width of a projection formed in other areas.

[Claim 11] The reflection-type liquid crystal display device as set forth in any one of claims 1 to 10, wherein liquid crystal is driven in accordance with active matrix in which a thin film transistor as a switching device is fabricated for each of pixels.

[Claim 12] A method of fabricating A reflection-type liquid crystal display device comprising a liquid crystal layer sandwiched between a lower substrate and an opposing substrate arranged to face each other, and a reflection electrode which is formed on said lower substrate and at which an external incident light is reflected towards a viewer as a light source,

characterized by the steps of:

forming a switching device and a wiring layer on an electrically insulating substrate of said lower substrate;

forming a plurality of projections on said wiring layer and said electrically insulating substrate in order to have said reflection electrode had a wavy surface;

forming an electrically insulating layer on said electrically insulating substrate to cover said projections therewith for making a smooth wavy surface; and

forming an electrically conductive thin film on said electrically insulating layer in alignment with said reflection electrode to form said reflection electrode so as not to overlap said wiring layer.

[Claim 13] The method as set forth in claim 12, wherein said projection causes an upper portion of said wiring layer to have a thickness equal to or greater than a projection in a wavy surface of said reflection electrode, while said electrically insulating layer is being formed.

[Claim 14] The method as set forth in claim 12 or 13, wherein after formation of a resist pattern for said reflection electrode, said reflection is etched long to make a resultant pattern smaller in width than said resist pattern, while said electrically insulating layer is being formed.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The invention relates to a reflection type liquid crystal display device and a method of fabricating the same, and more particularly to a reflection type liquid crystal display device in which an external incident light is reflected towards a viewer such that the reflected light acts as a light source, and a method of fabricating the same.

[0002]

[Prior Art]

As one of liquid crystal display devices, there is known a reflection type

liquid crystal display device. The reflection type liquid crystal display device includes a reflection plate at which an external incident light is reflected towards a viewer, and hence, is not necessary to include a back light source.

[0003]

FIG. 9 is partial cross-sectional view of a conventional reflection type liquid crystal display device. As illustrated in FIG. 9, the reflection type LCD 1 is comprised of a lower substrate 2, and an opposing substrate 4 facing the lower substrate 2 with a liquid crystal layer 3 being sandwiched therebetween.

[0004]

The lower substrate 2 includes a semiconductor device 5, a drain wiring 6, and projections 7 all formed on an electrically insulating substrate 2a. An electrically insulating layer 8 covers the semiconductor device 5, the drain wiring 6 and the projections 7 therewith, and a reflection electrode (reflection plate) 9 is formed on the electrically insulating layer 8. The opposing substrate 4 includes an electrically insulating substrate 4a, and a transparent electrode 4b formed on the substrate 4a, facing the liquid crystal layer 3.

[0005]

The electrically insulating layer 8 is composed of organic material, inorganic material or a combination of organic and inorganic materials. The electrically insulating layer 8 formed on the drain wiring 6 acts as an insulating film when wavy portions are formed at the electrically insulating substrate 2a, or a passivation layer for protecting the semiconductor device 5.

[0006]

[Problem to be solved by the Invention]

However, since the drain wiring 6 is covered only with the thin electrically insulating layer 8 (see FIG. 9), if a continuous pattern of the projection 7 is not formed on the drain wiring 6, a light reflected at the drain wiring 6 is unavoidably yellowish in color, resulting in harmful influence to the display characteristic of the reflection type LCD 1.

[0007]

FIG. 10 illustrates how lights are reflected in the reflection type LCD illustrated in FIG. 9. As illustrated in FIG. 10, an incident light Li passes through the opposing substrate 4 and the liquid crystal layer 3, reach the lower substrate 2, and is reflected at the lower substrate 2. The reflected light Lr passes through the liquid crystal layer 3 again, and leave the opposing substrate 4.

[0008]

If the drain wiring 6 composed of metal is covered only with the thin insulating layer 8, a space between the drain wiring 6 and the opposing substrate 4 sandwiching the liquid crystal layer 3 therebetween is greater than a space between the reflection electrode 9 and the opposing substrate 4. As a result, the light Lr reflected at the drain wiring 6 would have a greater birefringence rate ($\Delta n \times d$) than that of the light Lr reflected at the reflection electrode 9, and accordingly, the reflected light Lr would be yellowish. This causes a problem that when a white image is displayed, the white image would be yellowish.

[0009]

It is an object of the present invention to provide a liquid crystal display device and a method of fabricating the same both of which are capable of preventing a reflected light from becoming yellowish to thereby prevent a white image from becoming yellowish.

[0010]

[Solution to the Problem]

In order to accomplish the above-mentioned object, the present invention provides a reflection-type liquid crystal display device comprising a liquid crystal layer sandwiched between a lower substrate and an opposing substrate arranged to face each other, and a reflection electrode which is formed on the lower substrate and at which an external incident light is reflected towards a viewer as a light source, characterized in that the lower substrate has

a flat surface at which the lower substrate makes contact with the liquid crystal layer such that a gap between the opposing substrate and the reflection electrode or between the opposing substrate and the lower substrate on which the reflection electrode is formed is constant.

[0011]

In accordance with the present invention, a surface at which the lower substrate and the liquid crystal layer make contact with each other is designed flat, and hence, a space between the reflection electrode or the lower substrate on which the reflection electrode is formed and the second substrate is constant. This ensures that a reflected incident light is prevented from being yellowish by the reflection electrode formed on the lower substrate, further ensuring a white image displayed in a screen is prevented from being yellowish.

[0012]

The method of fabricating a reflection type liquid crystal display device, in accordance with the present invention accomplishes fabrication of the above-mentioned liquid crystal display device.

[0013]

[Embodiments of the Invention]

Hereinbelow are explained embodiments in accordance with the present invention with reference to drawings.

[0014]

FIG. 1 is a partial cross-sectional view of the reflection type liquid crystal display device in accordance with the first embodiment of the present invention. As illustrated in FIG. 1, the reflection type liquid crystal display (LCD) device 10 is comprised of a lower substrate 11, a liquid crystal layer 12, and an opposing substrate 13 facing the lower substrate 11 with the liquid crystal layer 12 sandwiched therebetween.

[0015]

The liquid crystal display device 10 is an active matrix type liquid

crystal display device including, for instance, a thin film transistor (TFT) as a switching device in each of pixels.

[0016]

The lower substrate 11 includes an electrically insulating substrate 14, TFT 15, a drain wiring 16, a projection pattern 17, an electrically insulating layer 18, and a reflection electrode 19. TFT 15, the drain wiring 16 and the projection pattern 17 all formed on the electrically insulating substrate 14 are covered with the electrically insulating layer 18, and the electrically insulating layer 18 is formed with a contact hole therethrough reaching a source electrode of TFT 15.

[0017]

The reflection electrode 19 is formed on the electrically insulating layer 18 except the projection pattern 17 formed on the drain wiring 16. That is, the drain wiring 16 is covered with the projection pattern 17 and the electrically insulating layer 18, and the reflection electrode 19 overlaps the electrically insulating layer 18.

[0018]

The reflection electrode 19 is electrically connected to a source or drain electrode of TFT 15, and act as a reflector and a pixel electrode. An incident light is reflected at the reflection electrode 19 towards a viewer. That is, the thus reflected light acts as a light source.

[0019]

The opposing substrate 13 includes an electrically insulating substrate 20, and a transparent electrode 21 formed on the substrate 20 and facing the liquid crystal layer 12. A light enters the opposing substrate 13, passes through the liquid crystal layer 12, reaches the lower substrate 11, is reflected at the lower substrate 11, passes through the liquid crystal layer 12 again, and leaves LCD through the opposing substrate 13.

[0020]

FIG. 2 is a plan view of the projection pattern of FIG. 3 for a pixel. As

illustrated in FIG. 2, the projection pattern 17 is comprised of a plurality of linear projections 17a connecting with one another with certain bending angles and arranged within a rectangular frame.

[0021]

The reflection electrode 19 is formed on the electrically insulating layer having a wavy pattern defined by the projections 17, the reflection electrode 19 has a wavy surface reflecting the wavy pattern.

[0022]

The frame of the projection pattern 17 is designed to have a width defined by a projection 17b greater than a width of the linear projection 17a formed in other areas, in order to cover the drain wiring 16 therewith, and is arranged on the drain wiring 16. The electrically insulating film 18 covers the projection pattern 17 therewith.

[0023]

The electrically insulating film 18 of the reflection type LCD 10 is composed of organic material, inorganic material or a combination of organic and inorganic materials, and has a thickness above the drain wiring 16 equal to or greater than a projection of the wavy pattern of the reflection electrode 19 acting as a liquid crystal display area (a height of the projection located on the drain wiring 16 $\geqq$ a projection in the wavy pattern of the reflection electrode 19).

[0024]

By forming the projection pattern 17 and the electrically insulating layer 18 on the drain wiring 16, there is formed an electrically insulating layer having a wavy pattern including projections having rounded summits, on the drain wiring 16. Thus, the layer overlying the drain wiring 16 has a thickness equal to a thickness of the projection of the wavy pattern in the liquid crystal display area, and is not lower than a recessed portion of the wavy pattern.

[0025]

FIG. 3 shows how a light is reflected in the reflection type LCD

illustrated in FIG. 1. As illustrated in FIG. 3, an incident light Li enters the opposing substrate 13, passes through the liquid crystal layer 12, reaches the lower substrate 11, is reflected at the reflection electrode 19, passes the liquid crystal layer 12 again, and leaves the opposing electrode 13 as a reflected light Lr.

[0026]

Since the layers overlying the drain wiring 16 has a thickness equal to a thickness of the projection of the wavy pattern of the reflection electrode 19 acting as the liquid crystal display area in the reflection type LCD 10, a gap between the drain wiring 16 and the opposing substrate 13 sandwiching the liquid crystal layer 12 therebetween is not greater than a gap in other areas.

[0027]

That is, a surface at which the lower substrate 11 makes contact with the liquid crystal layer 12 is flat such that a gap between the opposing substrate 13 and the reflection electrode 19 or the lower substrate on which the reflection electrode 19 is formed is kept constant.

[0028]

Accordingly, the light Lr reflected at the drain wiring 16 has a birefringence rate different from a birefringence rate ($\Delta n \times d$) of the light Lr reflected at the reflection electrode 19 (see FIG. 9). As a result, the reflected light Lr having been reflected at the drain wiring 16 shifts to being bluish from being yellowish, ensuring that a white image is prevented from being yellowish.

[0029]

FIG. 4 shows a positional relation between the drain wiring and a pixel electrode in the reflection type LCD illustrated in FIG. 1. In the reflection type LCD e 10, as illustrated in FIG. 4, the projection pattern 17 and the electrically insulating film 18 are located in a gap defined by adjacent reflection electrodes 19 formed on the electrically insulating film 18 covering the projection pattern 17 therewith above the drain wiring 16, or above the drain wiring formed on the

lower substrate 11, such that the reflection (pixel) electrode 19 does not overlap the drain wiring 16 (see (a)).

[0030]

That is, in the reflection type LCD 10, the drain wiring 16 does not overlap the reflection electrode 19 (see the broken line in (b)), that is, an end of the drain wiring 16 is not in alignment with and hence spaced away from an end of the reflection electrode 19 (see the broken line in (a)).

[0031]

If the reflection electrode 19 overlaps the drain wiring 16, a parasitic capacity would be increased, resulting in fluctuation in a pixel voltage. In contrast, it is possible to prevent the parasitic capacity from increasing, ensuring prevention of fluctuation in a pixel electrode. Thus, the display characteristic is not harmfully influenced, even when two drain wirings have the same voltage polarity, for instance, in so-called gate line inversion drive.

[0032]

FIG. 5 is a set of cross-sectional views of the reflection type LCD 10 illustrated in FIG. 1, showing steps to be carried out for fabricating the reflection electrode. First, as illustrated in FIG. 5, TFT 15 and the drain wiring 16 are formed on the electrically insulating substrate 14 (see (a)).

[0033]

Then, after the drain wiring 16 has been formed, a plurality of the projection patterns 17 is formed on the electrically insulating substrate 14 in order to form the wavy pattern at a surface of the reflection electrode 19, for instance, by coating organic resin over the electrically insulating substrate 14, and carrying out exposure and development to thereby form a mask (see (b)). The projection pattern 17 is formed such that the frame of the projection pattern 17 is located on the drain wiring 16.

[0034]

Then, the electrically insulating film 18 composed of organic resin is

formed so as to cover the first and second projection 17 therewith. Then, the electrically insulating film 18 is formed with the contact hole by exposure and development (see (c)). The electrically insulating film 18 is formed such that the layers overlying the drain wiring 16 is equal to or greater than a projection portion of the wavy pattern of the reflection electrode 19 acting as a liquid crystal display area.

[0035]

Then, a thin electrically conductive film such as an aluminum (Al) film is formed covering the reflection electrode 19 therewith and filling the contact hole therewith. Then, the reflection electrode 19 acting as a reflection pixel electrode is formed by carrying out exposure and development (see (d)).

[0036]

In the fabrication of the reflection electrode 19, the drain wiring 16 is designed not to overlap the reflection electrode 19. The reflection electrode 19 may be composed of any other electrical conductor in place of Al.

[0037]

FIG. 6 is a view showing steps (example 1) to be carried out for forming the reflection electrode illustrated in FIG. 5. First, as illustrated in FIG. 6, a resist pattern 22 for the reflection electrode 19 is formed (see (a)), and then, the reflection electrode 19 is etched for such a period of time that an aluminum thin film is much etched and resultingly a resultant pattern have a width smaller than a width of the resist pattern 22 (see (b)). Thus, the reflection electrode 19 can be formed so as not to overlap the drain wiring 16.

[0038]

FIG. 7 is a view showing steps (example 2) to be carried out for forming the reflection electrode illustrated in FIG. 5. As illustrated in FIG. 7, a resist pattern 22 of the reflection electrode 19 is formed so as not to overlap the drain wiring 16 in example 2. A mask is so designed (see (a)) or a resist is developed in a long period of time (see (b)) to prevent the reflection electrode from

overlapping the drain wiring. Thus, the reflection electrode 19 can be formed such that the reflection electrode 19 does not overlap the drain wiring 16.

[0039]

The layer overlying the drain wiring 16 has a thickness equal to or greater than a thickness of a raised portion of the wavy pattern of the reflection electrode 19. The method of doing so is explained hereinbelow.

[0040]

FIG. 8 shows a relation between a width of a mask pattern and a width of the projection pattern. As shown in FIG. 8, if a mask pattern had a width of 4 μm, the projection would have a width of about 7 μm and a height of about 2.2 μm, and if a mask pattern had a width of 10 μm, projection would have a width of about 10 μm and a height of about 2.8 μm.

[0041]

That is, the greater a width of a mask pattern is, the greater a height of the projection 17 is. Hence, the electrically insulating film could be thicker by designing a mask pattern for forming the projection 17 on the drain wiring 16 to have a width greater than a width of a mask pattern formed in an area of the reflection electrode 19.

[0042]

When the projection pattern is to be composed of acrylic resin, the projection on the drain wiring 16 can be designed to have a thickness equal to or greater than a thickness of the projections of the wavy pattern of the reflection electrode 19.

[0043]

The wider a line width of a photoresist pattern is, the greater a height of a projection composed of acrylic resin is after being baked. By utilizing this phenomenon, the projection pattern formed on the drain wiring 19 could be designed to have a width than the same in the liquid crystal display area and a thickness greater than the projections of the wavy pattern.

[0044]

As mentioned above, the reflection type LCD 10 has such a structure that the electrically insulating film having a rounded summit is formed above the drain wiring 16, that the reflection electrode 19 does not overlap the drain wiring 16, and that the projection pattern 17 formed above the drain wiring 16 is wider in width than a width of the projection pattern formed in an area in which the reflection electrode is formed, and hence, is higher than the projection formed in an area in which the reflection electrode is formed.

[0045]

That is, the projection pattern 17 and the electrically insulating film 18 covering the projection pattern therewith are formed on the drain wiring 16 in order to uniformize an average thickness of the liquid crystal layer 12, and the electrically insulating film 18 is formed between the adjacent reflection electrodes 19 such that the reflection electrode 19 does not overlap the drain wiring 16, in order to reduce a parasitic capacity.

[0046]

Thus, the electrically insulating layer 18 formed above the drain wiring 16 to cover the projection pattern 17 therewith is formed such that end surfaces of the reflection electrode 19 do not overlap extensions of opposite sides of the drain wiring 16, and have almost the same height as a height of the reflection electrode 19.

[0047]

Though it is ideal that a distance between pixel electrodes (reflection electrodes 19) is greater than a width of the drain wiring 16, end surface of the reflection electrode 19 may be in alignment with opposite sides of the drain wiring 16. At least, if opposite end surfaces of the reflection electrode 19 do not overlap extensions of opposite sides of the drain wiring 16, it would be possible to obtain requisite advantages. For instance, even if one of opposite end surfaces of the reflection electrode 19 overlap the extensions due to misalignment, it

would be possible to obtain requisite advantages, if they are flat.

[0048]

In the present invention, as mentioned above, the projection pattern 17 and the electrically insulating film 18 partially form the wavy surface of the reflection electrode 19, the reflection electrode 19 is formed not to overlap the drain wiring 16, and is formed higher than the projections in the liquid crystal display area such that the reflection electrode 19 does not overlap the drain wiring 16 and the electrically insulating film 18 and the reflection electrode 19 are flat.

[0049]

As a result, it is possible to prevent the reflected light Lr reflected at the drain wiring 16 from being yellowish, and further possible to prevent a white image displayed in a display screen from being yellowish.

[0050]

That is, it is possible to reduce parasitic capacity which exerts harmful influence on the display characteristic, when two drain wirings have the same voltage polarity, for instance, in the gate line inversion drive, and further possible to improve a color of a light reflected at the drain wiring 16, ensuring enhancement of the display characteristic.

[0051]

In the above-mentioned embodiment, though TFT 15 is used as a switching device, a diode or other switching devices may be used. In addition, a film thickness may be controlled by forming the projection pattern 17 and the electrically insulating film 18 not only on the drain wiring 16, but also other wirings composed of metal.

[0052]

[Advantages obtained by the Invention]

As mentioned above, in accordance with the present invention, a surface at which the lower substrate and the liquid crystal layer make contact

with each other is designed flat, and hence, a space between the reflection electrode or the lower substrate on which the reflection electrode is formed and the second substrate is constant. This ensures that a reflected incident light is prevented from being yellowish by the reflection electrode formed on the lower substrate, further ensuring a white image displayed in a screen is prevented from being yellowish.

[0053]

The reflection type liquid crystal display device and the method of fabricating the same both in accordance with the present invention accomplishes the above-mentioned reflection type liquid crystal display device and method of fabricating the same.

[Brief Description of the Drawings]

[FIG. 1]

FIG. 1 is a partial cross-sectional view of the reflection type liquid crystal display device in accordance with the first embodiment of the present invention.

[FIG. 2]

FIG. 2 is a plan view of a pattern of projection within a pixel in FIG. 1.

[FIG. 3]

FIG. 3 illustrates how a light is reflected in the reflection type LCD illustrated in FIG. 1.

[FIG. 4]

FIG. 4 is a cross-sectional view showing a positional relation between the drain wiring and the reflection electrode in the reflection type LCD illustrated in FIG. 1.

[FIG. 5]

FIG. 5 is a cross-sectional view showing steps to be carried out for fabricating the reflection electrode in the method of fabricating the reflection type liquid crystal display illustrated in FIG. 1.

[FIG. 6]

FIG. 6 shows steps (example 1) to be carried out for forming the reflection electrode illustrated in FIG. 5.

[FIG. 7]

FIG. 7 shows steps (example 2) to be carried out for forming the reflection electrode illustrated in FIG. 5.

[FIG. 8]

FIG. 8 is a graph showing a relation between a width of a mask pattern and a cross-section of the resultant projection pattern.

[FIG. 9]

FIG. 9 is a partial cross-sectional view of the conventional liquid crystal display device.

[FIG. 10]

FIG. 10 illustrates how a light is reflected in the reflection type LCD illustrated in FIG. 9.

[Indication by Reference Numerals]

10 Reflection type LCD

11 Lower substrate

12 Liquid crystal layer

13 Opposing substrate

14 Electrically insulating substrate

15 TFT

16 Drain wiring

17 Projection pattern

17a Linear projection

17b Frame projection

18 Electrically insulating layer

19 Reflection electrode

20 Electrically insulating substrate

21 Transparent electrode

22 Resist pattern

Li Incident light

Lr Reflected light

[Document Name] Abstract

[Abstract]

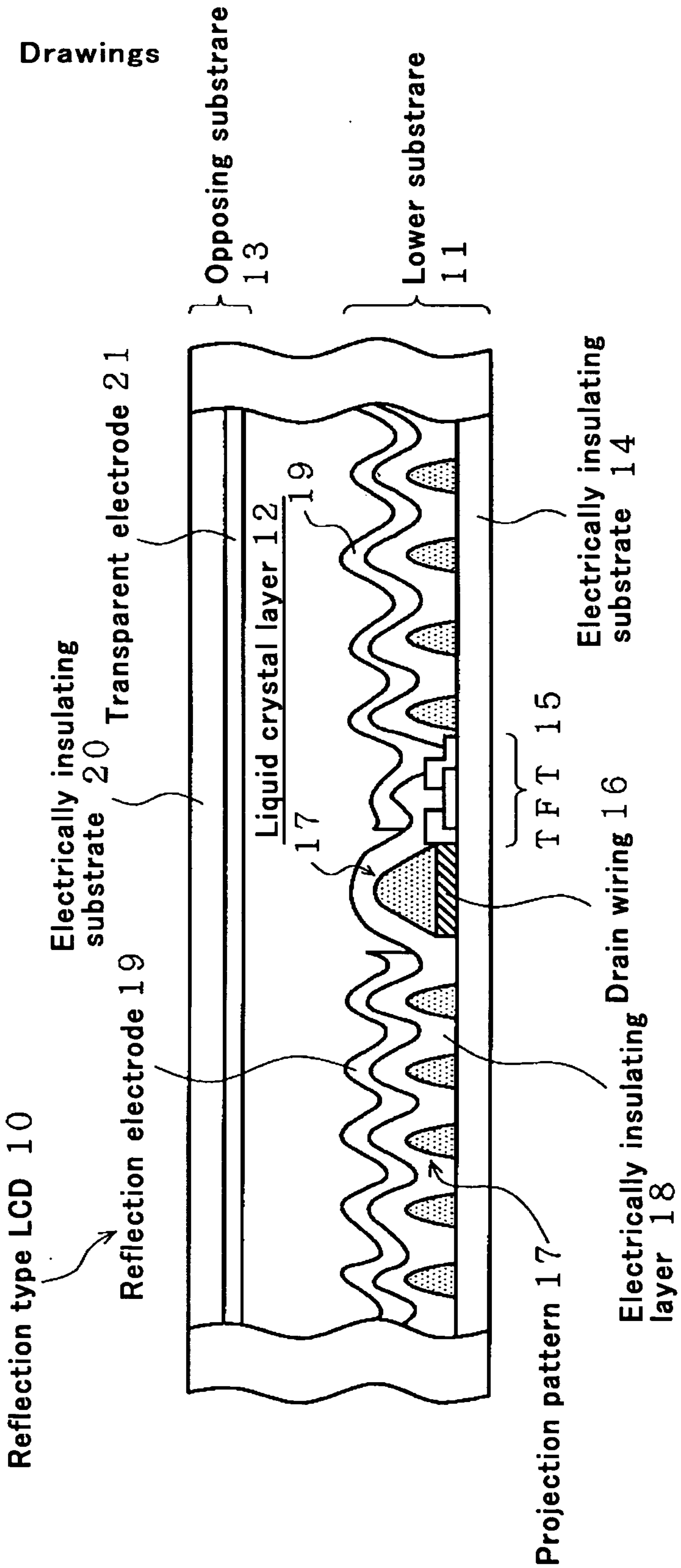
[Object] To provide a liquid crystal display device and a method of fabricating the same both of which are capable of preventing a reflected light from becoming yellowish to thereby prevent a white image from becoming yellowish.

[Solution] The reflection-type liquid crystal display device includes a liquid crystal layer 12 sandwiched between a lower substrate 11 and an opposing substrate 13 arranged to face each other, and a reflection electrode 19 which is formed on the lower substrate 11 and at which an external incident light Li is reflected towards a viewer as a light source, and is characterized in that the lower substrate 11 has a flat surface at which the lower substrate 11 makes contact with the liquid crystal layer 12 such that a gap between the opposing substrate 13 and the reflection electrode 19 or between the opposing substrate and the lower substrate 11 on which the reflection electrode 19 is formed is constant.

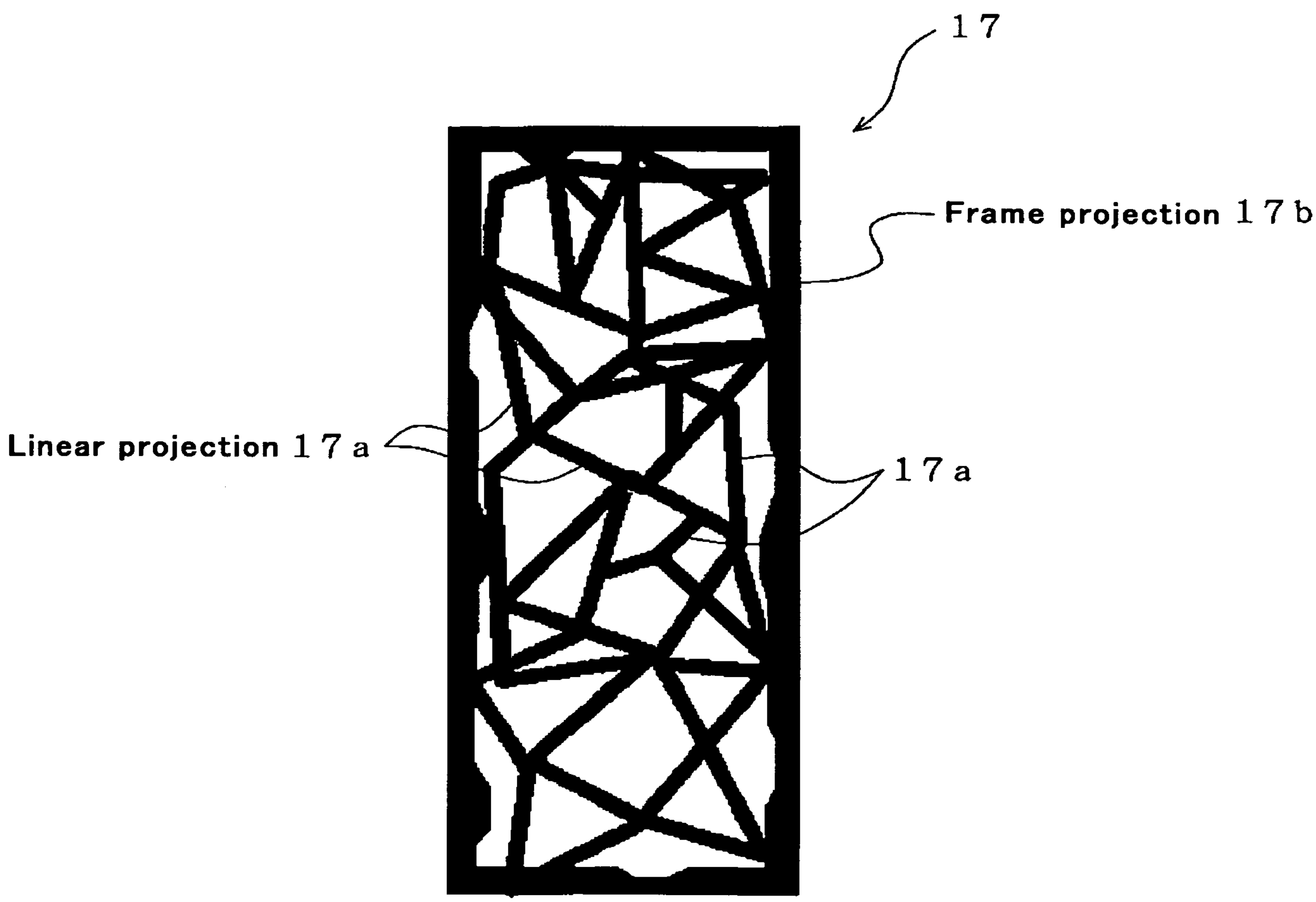
[Representative Drawing] FIG. 1

【Document Name】 Drawings

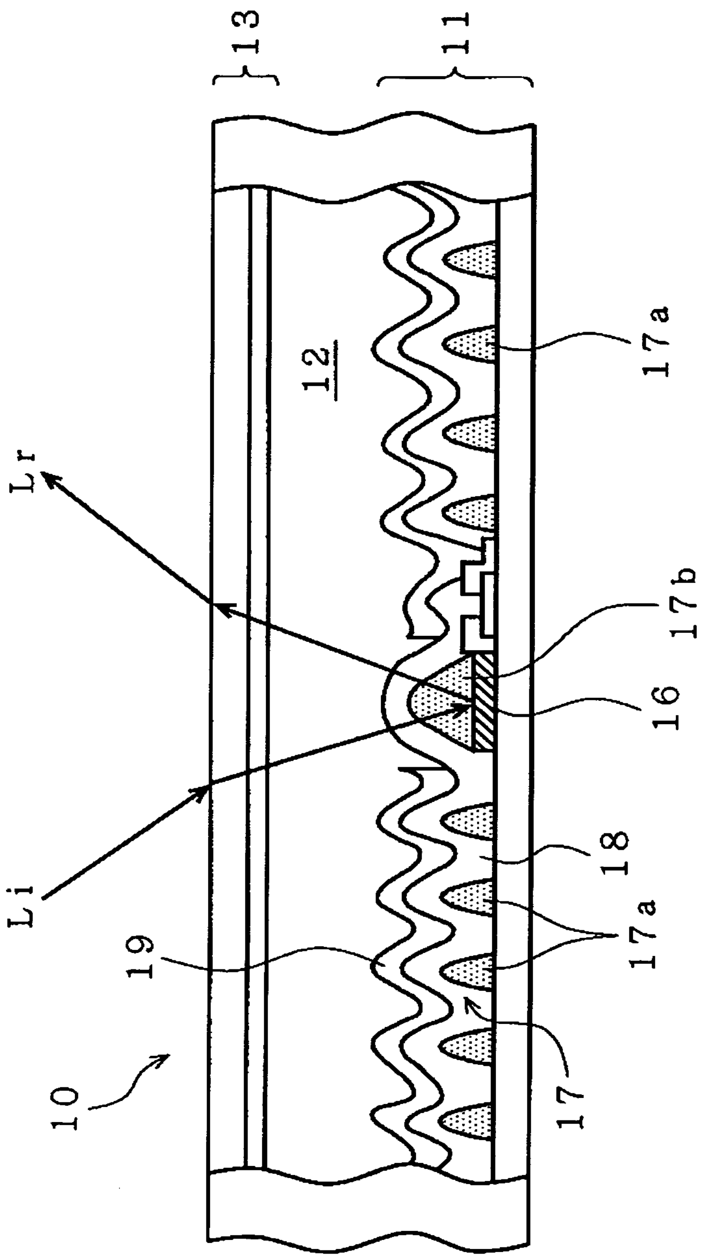
【Fig.1】



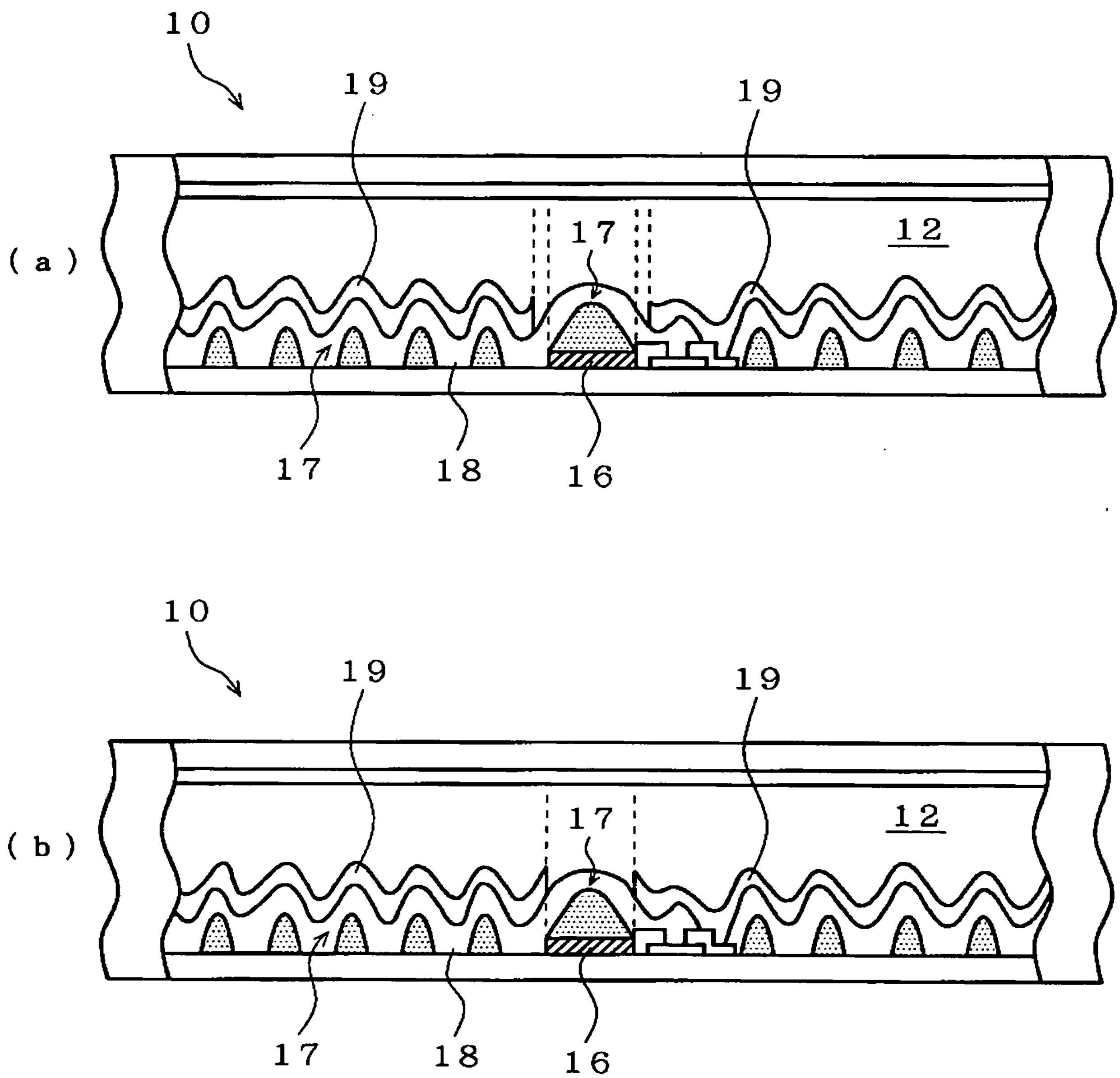
【Fig.2】



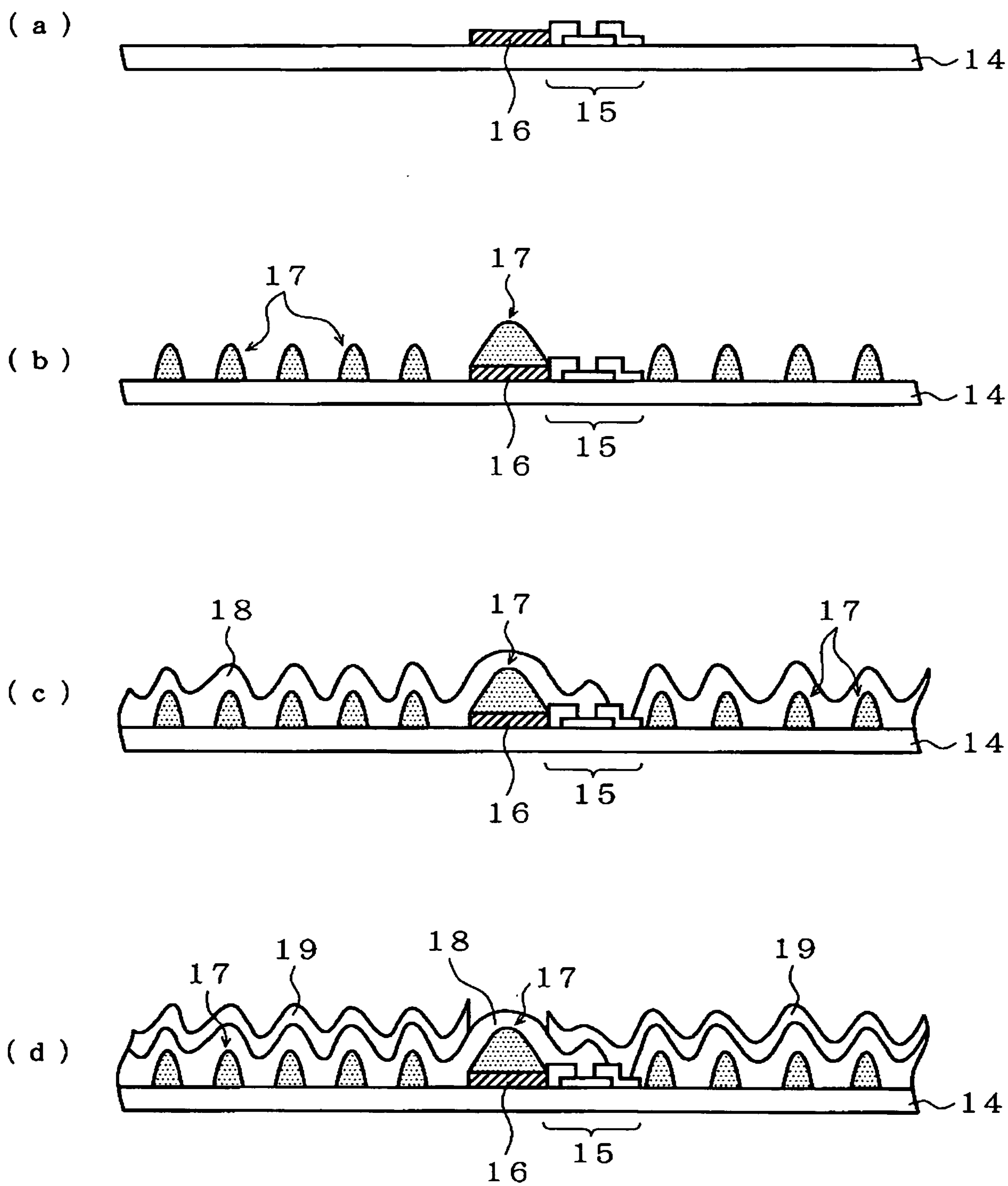
【Fig.3】



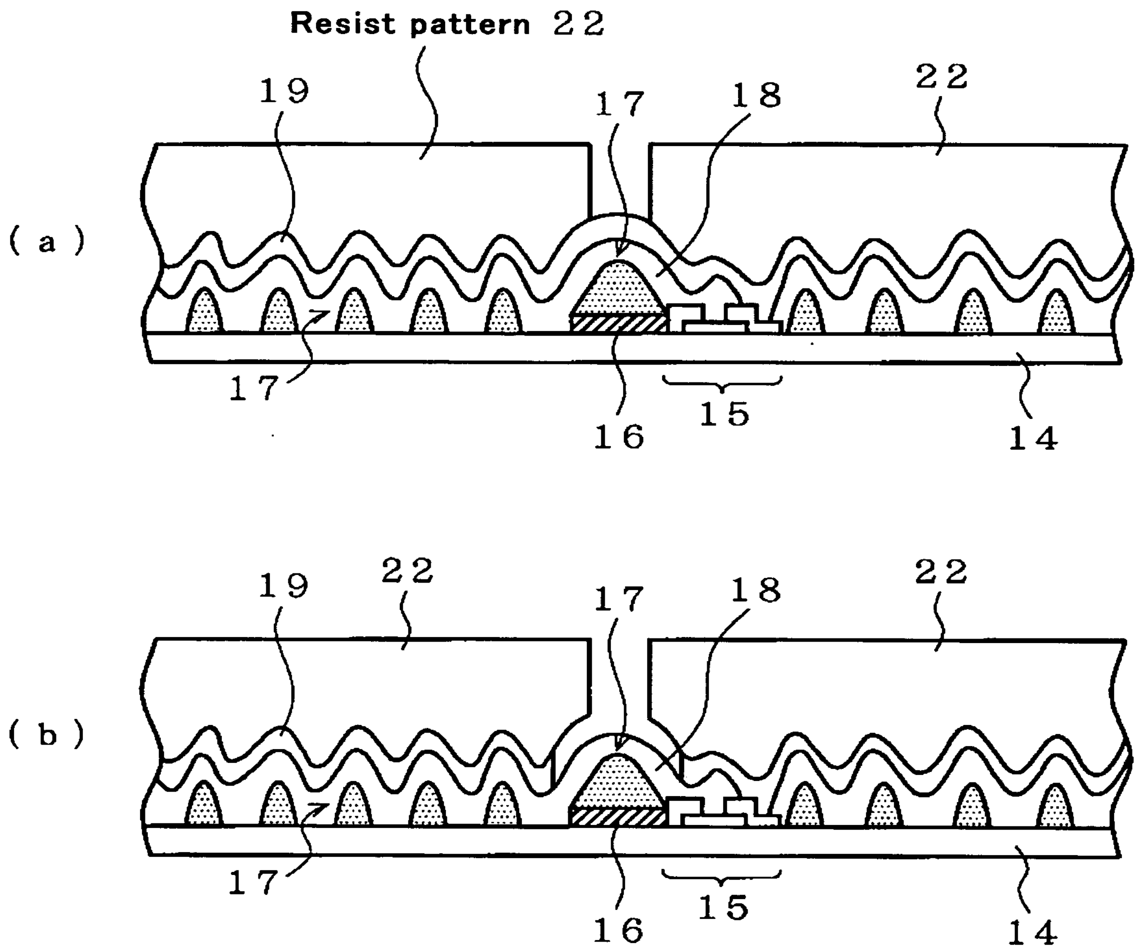
【Fig.4】



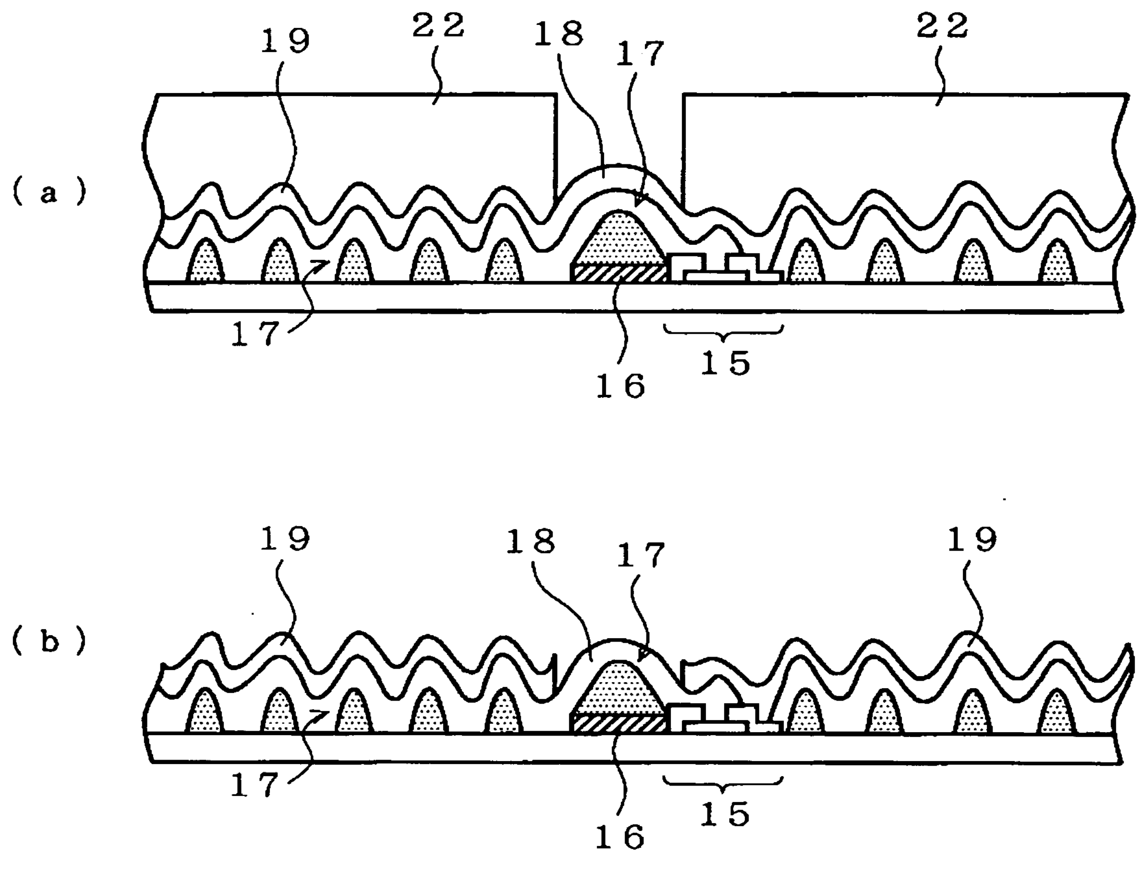
【Fig.5】



【Fig.6】

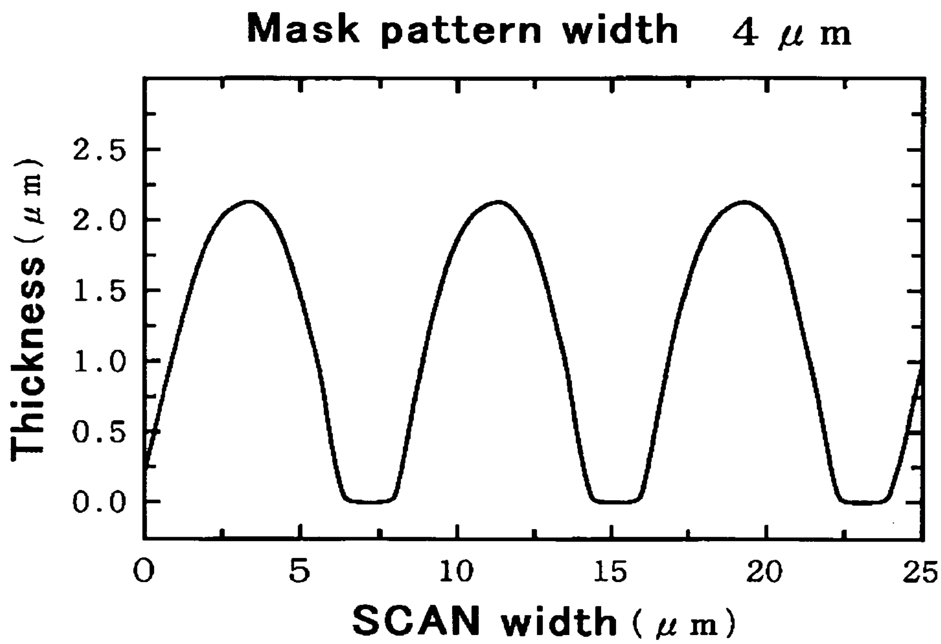

Resist pattern 22
19
17
18
22
(a)
17
16
15
14
19
22
17
18
22
(b)
17
16
15
14

【Fig.7】

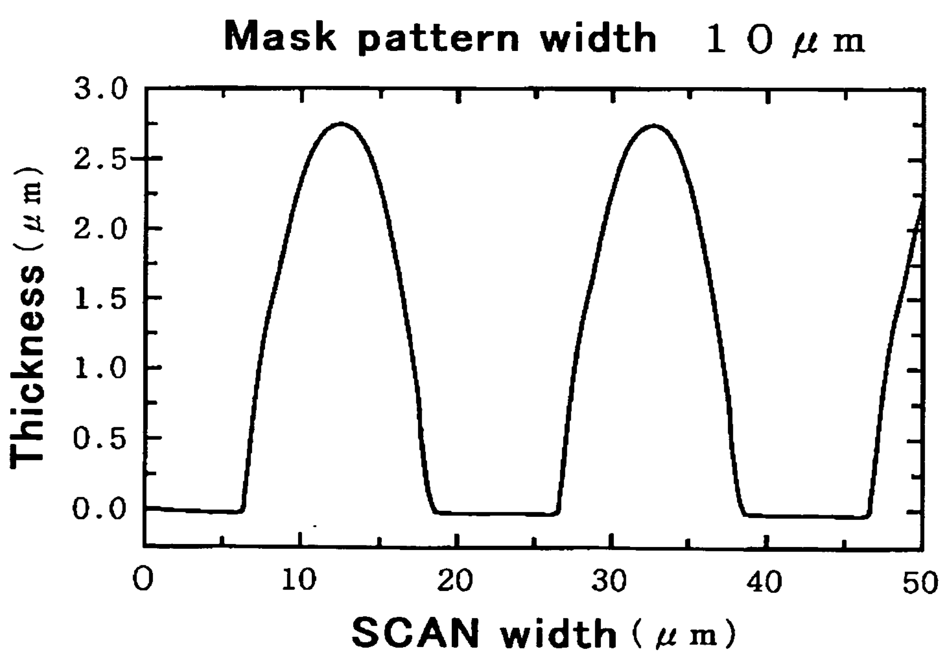


【Fig.8】

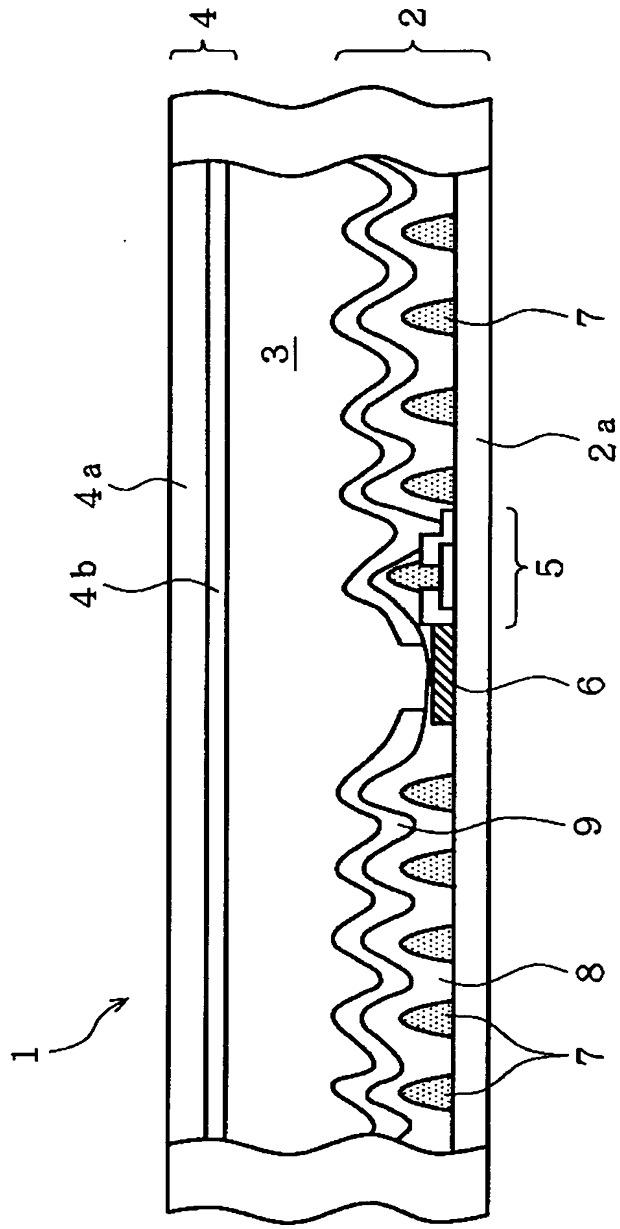
(a)


Mask pattern width 4 μm
Thickness (μm)
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
SCAN width (μm)

(b)


Mask pattern width 10 μm
Thickness (μm)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
SCAN width (μm)

【Fig.9】



【Fig.10】